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THE NEW JERSEY SALT MARSH AND
ITS IMPROVEMENT

NEW JERSEY

AGRICULTURAL

Experiment Stations

207

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS

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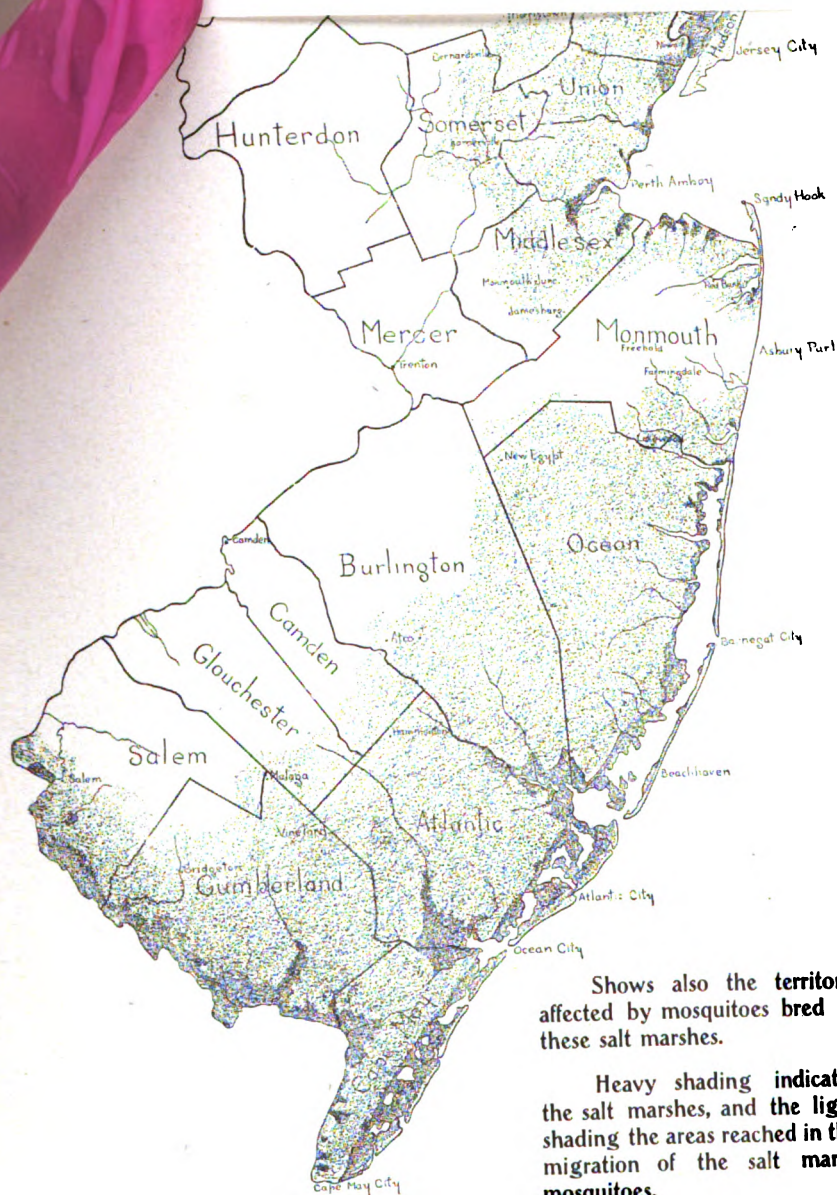
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The Sa Areas o New Je



Shows also the territory affected by mosquitoes bred in these salt marshes.

Heavy shading indicates the salt marshes, and the light shading the areas reached in the migration of the salt marsh mosquitoes.

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS BULLETIN 207

NOVEMBER 14, 1907.

The New Jersey Salt Marsh and its Improvement.

BY
JOHN B. SMITH, Sc.D.

Introductory Statement.

At a hearing provided for by the Senate committee having in charge the bill providing for locating and abolishing mosquito-breeding salt-marsh areas, it was urged that in addition to the direct advantage to the State of the eradication of the mosquitoes the indirect returns that would be derived from the drainage necessary in abolishing the mosquito-breeding areas would, in a few years, exceed the total appropriations asked for.

This argument was based on the assumption that the water-logged marsh areas, now largely waste lands, would then grow instead, grasses of commercial value. No definite statement could be made as to the area likely to be improved, nor its possible increase in value.

In order to obtain more definite information on this point, I authorized Professor J. B. Smith, the executive officer in charge of the mosquito work, to make such observations and investigations of the areas already drained, as would serve as a basis for estimating the possible value to the State of the drainage work. His report, herewith, verifies the statement made in reference to the possible increase in land values to be derived from the drainage provided for in the law, as well as the difficulties that are involved

in the drainage of all of the tide-marsh areas. This matter is of great importance to the State and warrants further investigation of the subject.

E. B. VOORHEES,
Director.

In volume IV. of the final report of the State Geologist, in 1895, the area of the State is summarized in part as follows:

	<i>Square Miles.</i>	<i>Acres.</i>
The State	8,224.44	5,263,641
Land surface	7,514.40	4,809,218
Water surface	710.04	454,423
Upland, including fresh-water swamps, ...	7,022.76	4,494,567
Tide marsh	462.95	296,289
Beach	28.36	18,151

Of the tide marsh it is said that 34,304 acres are embanked and more or less improved. The embanked area is located as follows:

	<i>Acres.</i>
Burlington county	299
Cape May county	1,402
Cumberland county	7,142
Gloucester county	3,558
Hudson county	4,045
Salem county	15,225
	31,671

This enumeration leaves out of account about 2,700 acres which are probably distributed in small lots in the other shore counties.

Elsewhere, in the same report, it is stated that "the area of tide marsh in the State, including creeks less than 100 yards in width, is 296,500 acres. The included bays and creeks over 100 yards wide cover 125,570 acres, making a total of about 660 square miles for the whole tidal plain. The marsh corresponds in elevation generally to the level of the highest tide, since when it ceases to be overflowed it ceases to receive sediment and increase in elevation. This level does not necessarily correspond with high-water level in the ocean, however, for high water in the bays is usually much lower. The inlets are too contracted to allow the bays to fill up to the level of high water outside, so high water inside of the beaches ranged from one to nearly two feet lower. It is not un-

usual, therefore, to find the marsh more than a foot lower than mean high water in the ocean outside. For the same reason the marsh is found to be low near the upland at the head of the long tidal creeks on Delaware bay shore.

"Where the marshes have been embanked and improved they have shrunk considerably. Instances have been noted where this shrinkage or settlement amounts to three feet."

As to this "improved" marsh area, the improvement is in some cases merely nominal. The 4,045 acres credited to Hudson county, for instance, were until the present year as absolutely useless as any unimproved marsh within the State, and as virulent breeders of mosquitoes. Neither Essex nor Union county is specifically credited with any improved area, yet part of their marsh was at one period in process of such reclamation as was attempted for Hudson county.

According to Mr. Henry B. Kümmel, the State Geologist, the Atlantic coast line, from Sandy Hook to Cape May Point, is between 127 and 128 miles—most of it adapted for summer resorts—and from Cape May Point to the mouth of Salem creek, along the line of the Delaware bay and river, it is close to fifty-nine miles. There is no true salt marsh north of Salem creek, and that point marks the end of the investigations, the results of which are here given. Tidal marsh extends north of this point, but the area is not great and the marsh differs totally in character.

Location of the Salt Marsh.

The salt-marsh areas in New Jersey begin, at the north, around the shores of Newark bay and extend for some distance along the Hackensack and Passaic rivers. There is no salt marsh on the shores of the Hudson river, and none, at present, in New Jersey on New York bay. It extends along the shores of the Arthur Kill, and inland along the shores of the rivers that empty into it. There is more or less marsh along the shores of the Raritan bay at points where there are indentations and where small creeks empty into the bay, and for several miles along both shores of the Raritan river there are extensive flats. The shores of the Navesink are clean, but the Shrewsbury river has low, swampy banks, covering some distance between the highland and shore. Then comes a stretch of coast line, extending from the Atlantic Highlands to Bay

Head, along which the main land comes to the shore; the beach is abrupt, the sand brown and coarse and there is no marsh except a little on the banks of the Shark river, which scarcely counts. Beginning at Bay Head, the edge of the mainland bends to the east; but the southward trend of the coast is continued by a sand bar which continues the line of the coast almost rigidly to Barnegat inlet. This sand bar varies in width, from a few hundred feet to a mile, has a sloping shore of white fine sand to the Atlantic ocean, no great elevation at any point and a low flat surface to the west. At Barnegat inlet the line of the sand bar extends decidedly more west, so as to make a course distinctly northeast and southwest, about half south, to the new inlet at Great bay. Bending still more westerly from this point it extends with ever more numerous breaks or inlets to Cape May City. Between this narrow sand bar and the mainland the distance varies from one mile to seven, and this may be open water, as in Barnegat, Egg Harbor and Great bays, or it may be mostly a succession of sounds, thoroughfares and creeks between low islands of salt-marsh flats, as is the case south of Great bay. On the west shore of the coastal bar is a strip of marsh varying in width, but mostly narrow. The shore of the mainland is bordered by flats, varying from a few hundred feet to nearly two miles in width, before the open water is reached, and on both sides of the Mullica, Bass and Great Egg Harbor rivers there are very broad stretches of salt meadow, more or less cut up with creeks.

Along the line of the Delaware bay and river there is no fringe of sand bar. The marsh here comes directly to the shore and extends back to the highland from one to five miles away. This marsh is not nearly so much cut up by creeks and streams, and the Maurice river and Cohansey creek are the only large water courses that cut it and offer a chance for an inland extension to any greater distance.

The relief map, which accompanies this Bulletin, brings out these points more fully and shows more clearly than any description the exact location of the marsh areas—colored blue over blue lines.

Kinds of Salt Marsh.

Roughly speaking, there are three general types of marsh included in the total estimate, but just how much there is of each cannot be definitely stated at present.

The first and smallest in area is that which is covered at every mean high tide and which may or may not be covered with sedge or joint grass. It is an area that has never been made useful for any purpose, is not dangerous as a mosquito-breeding territory, is gradually rising or making up and is more plentiful south of Great bay. It merges gradually into the second type.

The second type is in area rarely covered at ordinary tides, but so little above mean high water that even the slightest rise, due to wind, storm or moon changes, results in a watery covering. Such areas may be covered by sedge, but more usually have a scanty growth of the joint grass and are inhabited by fiddler crabs. This area is also without present value and is not dangerous as a mosquito breeder, for the burrows of the "fiddlers" provide effective drainage. Such marsh is usually very flat and level, and if holes occur they are of considerable size and naturally and continually stocked with fish and other marine organisms. This type of marsh is also more general south of Barnegat bay and is also gradually rising. The surface is quite generally a slippery mud, and there is not even enough shelter to tempt adult mosquitoes to rest on it.

The third type of marsh is all that area above mean high tide and more or less completely covered with vegetation. All true marsh is likely to be covered by the spring and fall tides, and winter or storm tides reach every part of it. It is almost always cut by creeks and waterways of varying width and these usually have abrupt, sharply defined banks, making them excellent as outlets for ditches. Where this marsh is broad, it tends to be higher at its creek or bay edge and to become lower toward the border of the highland. This feature has been referred to in the geological report, as already cited, and is important, because it furnishes a basin in which water is apt to lodge and in which holes form that rot the vegetation and tend to enlarge. Such areas also form the most prolific source of mosquito broods. I have in mind a case where I walked for nearly a mile, from the bay shore toward the highland across a high level marsh, on which there was not a mosquito pool visible. Just before the mainland was reached the marsh dipped and for a quarter of a mile there was a succession of holes and water-filled shallows in which there were wrigglers in uncountable numbers. Mean high tides do not reach this area; but full moon and storm tides do, especially in spring and fall. The water gets there from the creeks and other channels, sifted

through grass and vegetation that keep out the fish, and, once in, it stays there until it evaporates. Under the rays of the sun it warms rapidly and is then in ideal condition to breed mosquitoes. Winter conditions of frost, ice and snow keep such an area in a water-logged condition and make it useless for all agricultural purposes while it frequently serves also as a bar to reaching the better marsh areas.

Vegetation on the Marshes.

These marshes are botanically quite interesting and a large number of plants can be collected on them; but from the practical standpoint there are only a few that need be noted. From the very beginning, when these flats rise above the surface at any stage of the tide, some vegetation begins to cover it. At low tide there may be an island of tall sedge; at high tide the tips of the grasses only will appear above the water. All these sedge grasses are thick stalked and have large roots that extend deep into the mud to maintain themselves. They die down each year and new shoots come up; mud and other materials lodge ever more at the base of the stems and gradually build up the surface until, from an area of the first type, it passes into one of the second. Those grasses that maintained themselves under previous conditions die out and rot down, leaving as a memory of their occupation a mass of roots and stalks several inches thick and this forms the firm surface of the marsh, covered though it may be by a coating of mud or ooze. Other plants now begin to come in. Among the first is the joint grass and an occasional reed or rush of a small size. Most commonly, however, the three-square grass makes its appearance and becomes gradually more abundant. This also has a vigorous root system, and as it comes up each year from seed covered by the mud and other deposits of the winter and spring, it also adds, very slowly, to the height of the marsh and to the root mass already in the soil and which does not decay, tending rather to form a peat or turf. Other coarse grasses come in as the marsh increases in height and, finally, the salt grass gets a footing. Up to that time the marsh has been useless, agriculturally; but the salt grass is valuable for packing, for bedding and to a less extent for feeding. When the salt grass has possession of the meadow, it becomes a paying piece of property, rightly managed. Salt grass grows only in marshes that are so high above ordinary tides that flooding is

only occasional. It will not grow where the three-square grass flourishes, but is its next successor in regular course. As the marsh continues to rise, it tends to become irregular from causes that are too complex to be detailed here, and when it has reached the proper stage of dryness the black grass makes its appearance. This grass is the most valuable of all those that grow on the salt marshes and is readily eaten by stock that will take only a small amount of the salt grass. The difference in value as between salt and black grass at present writing is \$2 per ton. Beyond this stage, the meadow does not go under natural conditions. As it rises and less water gets on it, it even tends to deteriorate. Other plants find entrance, the water lodges here and there and holes rot out until the meadow becomes "rotten." This condition forms most readily at the points furthest from the water, as already noted, and when the free movement of the water becomes interrupted.

From the explanation just given, the composition of the average salt meadow will be readily understood. The upper layer, extending from twelve to eighteen inches, is a huge sponge composed of a mass of roots and vegetable material. It is a real turf and may be used as such. Indeed, on some of the marshes, which have been ditched in the course of the mosquito work, the sods taken out of the ditches have been piled up, dried and used as fuel by the owners of the land. Like any other sponge, this turf holds water and dries out slowly by surface evaporation; but give it a chance, and it will give up its liquid readily. A ditch cut six inches below the turf line will drain out all the water for 100 feet on each side, slowly at first until circulation lines have become established, but ever more rapidly until it finally runs out as through a sieve. Even a heavy rain leaves no trace, and when covered by a tide the water soaks out almost as fast as it can be carried off by the ditches. The deeper the ditch the better it acts.

At my request, Mr. H. H. Brehme, one of my assistants in the mosquito work, brought up from the Raritan meadow a machine-cut sod. It measured, when taken out, 10 x 10 x 27 inches and weighed 121 pounds. When partly dried out it was turned over to Dr. Jacob G. Lipman, in the department of soil investigation, and he furnishes the following description:

"Composition of sample of sod, 10 x 10 x 27, taken August 13th, 1907, on Raritan marsh opposite Sayreville:

"Original weight	121 lbs.
Dry weight	23.39 lbs.
Moisture	80.67 %
Dry matter	19.33 %

	<i>Upper Portion.</i>	<i>Lower Portion.</i>
Nitrogen	0.65 %	0.63 %
Organic matter	34.23 %	21.30 %
Ash	65.75 %	78.70 %

"The spongy fibrous character of the upper portion of the sod is gradually modified in its lower portion. The distinct root structure tends to disappear and with the darker color the entire mass becomes more compact and resembles muck rather than peat. The proportionate amount of carbon and ash are both increased, while the proportion of organic matter is diminished."

The upper and lower portions were each equal to one-half the depth of the sod; had it been divided into three equal portions the proportion of organic matter in the upper layer would have been more forcibly brought out.

The condition of affairs on the western side of the sand bar extending along shore is somewhat different. Here the basis is a sand flat, very little above the tide level, that by an accumulation of sea weed and wash has gradually formed a basis for short sedgey grasses quite different from those on the mud flats. These grasses grow in tufts, and root quite firmly in the sand, so that it is by no means an easy task to pull them out. Around such tufts of grasses vegetable matter lodges readily and forms the basis for the growth of other plants until gradually even here a peaty sod forms over the sand. But this sod is much thinner, as a rule, than that on the mud bottom, and rarely extends more than six inches below the surface, except in the broader and older areas, where it gets down to a foot, but equally rests on a sand bottom. After the meadow has once become elevated above the mean high-tide line, its progress as to the development of grasses is much the same, and both salt and black grass hay may be cut to good advantage. It is usually shorter, however, than that growing on mud bottoms. Meadows of this character are not so apt to become rotten, and remain more level. As the underlying sand is always more or less porous, the water sinks readily through the turf and into the sand beneath it.

Present Value of the Salt Marshes.

To say that the salt-marsh areas in New Jersey have no present value would not be strictly true, and yet not so far wrong, either. The taxable value is, of course, to some extent an index to actual value, and in by far the greater part of all communities containing them, salt marshes are either not taxed at all, or placed at a value so nominal as to add little to the income of the taxing body. Quite a number of owners of marsh areas of ten acres or under have told me that they had never paid any taxes, and had not been asked to pay any. In some townships there was no sort of record of ownership in the assessor's hands, and when it became a matter of serving notices it was almost—in many cases quite—impossible to find out who the owners were. I know, from personal knowledge, that owners of "from bay to shore" of some of the most desirable sea-shore property in the world paid in one year from thirty-five cents to \$1.05 as taxes on it. To be sure, as it lay it had no value. It was a stretch of shore backed by sand hills and followed by a stretch of marsh. It was a mile away from a railroad station, and inhabited chiefly by mosquitoes, who disputed any attempts to invade the territory, but the value in the land exists, and even in its present state it is capable of producing an income.

Under such conditions it is not surprising that townships consisting mainly of such territory, with hardly voters enough to get men who will consent to hold the offices, are in a state of chronic poverty, and that all propositions requiring the expenditure of money for improvements are voted down with sickening unanimity.

It is another curious evidence of the reputed value of salt-marsh land that none who work on them consider in the least the results of interference with the natural drainage or surface. Railroads build embankments across them and, except in the case of large creeks, pay no attention to the water courses. A small creek will be cut without even a culvert, and the head of that creek will stagnate and extend its bed into a pool. The marsh then becomes water-logged, a good hay meadow is in a year or two transformed into a quagmire, and no one protests, not even the owner!

Or a railroad needs sods to strengthen or increase its way across the meadow. They may be cut anywhere within convenient carting distance, without inquiry as to ownership of the land from which they are cut, and holes of all sizes, forms and depths are

scattered over the area. In the rarest cases these holes are connected with tidewater, and usually there remains merely a series of stagnant pools, more or less continuous mosquito breeders.

Roads of other kinds are usually run with the same disregard of drainage conditions, and almost every "improvement" of this character leaves the meadow in a worse and less valuable condition than it was before, and quite unnecessarily so.

In some of the smaller, more compact municipalities conditions are much better, and all the owners of the land are known; but even here values are low and the tax income is very small. It is fair to say that, as a whole, salt-marsh property in New Jersey is regarded as worth little or nothing.

Actual Value of Salt Marshes.

But does salt marsh have a real value from the actual practical standpoint, and can all salt marsh be made of actual value? The answer to these questions is, Yes, decidedly; all salt marsh of the third type may be made to produce an income of from \$10 to \$40 per acre annually, and all salt marsh of that type can be made of actual value.

As a matter of fact, there are many hundred acres that do produce such incomes as against many times more that produce nothing—but can be made to do as well.

The basis for these assertions is the information gained during the work done, under the direction of the writer, on marshes that were being drained for the extermination of mosquitoes, and the illustrations will be drawn from the results apparent in this work.

Effect of Drainage on Crops.

The Newark meadow has an area of about 3,500 acres, and hay has been cut on parts of it for many years. Before the 90's it was generally cut by men who wished to use it as food for stock or as bedding, and some ditches were cut by those who noticed that well-drained land produced much better crops than such as were either too dry or water-logged. After the 90's a number of banana-houses opened in Newark and created a demand for salt hay to use in layering the ripening fruit. This demand led to the cutting of

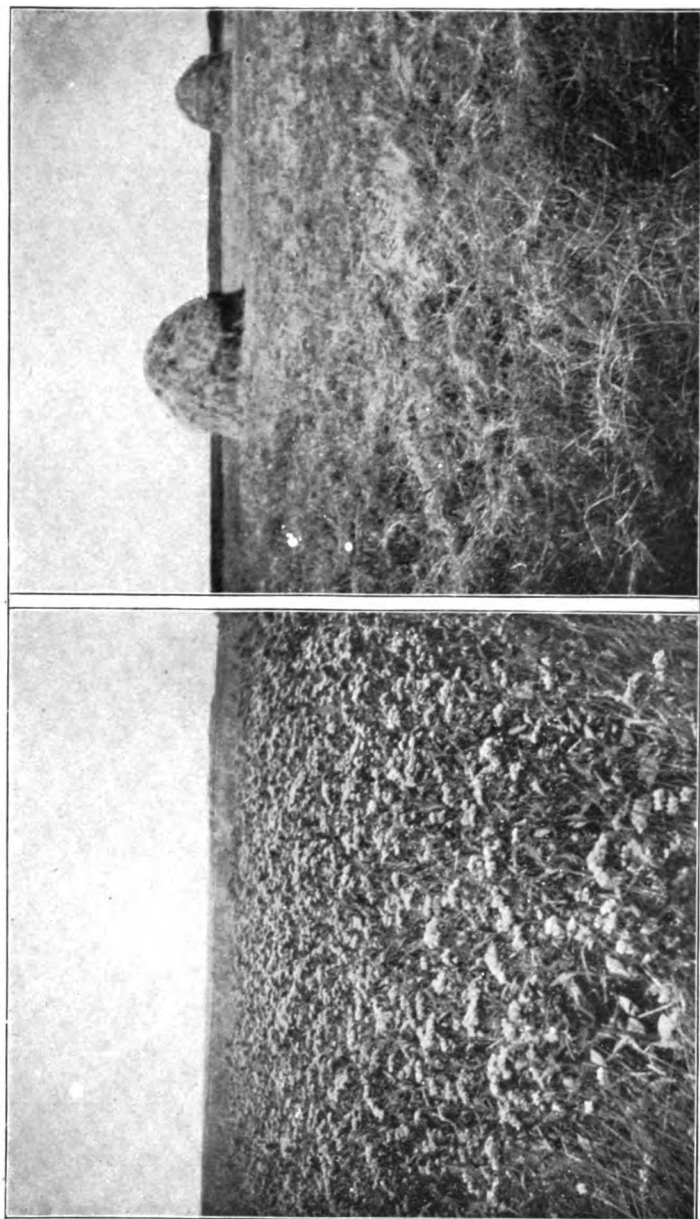


PLATE I.

To the left an area drained in the spring of 1907 after twenty years of water covering : now has a dense growth of salt-marsh fleabane. To the right an area of two acres with its crop of salt hay : before drainage, three and one-half tons was the best this area ever did.

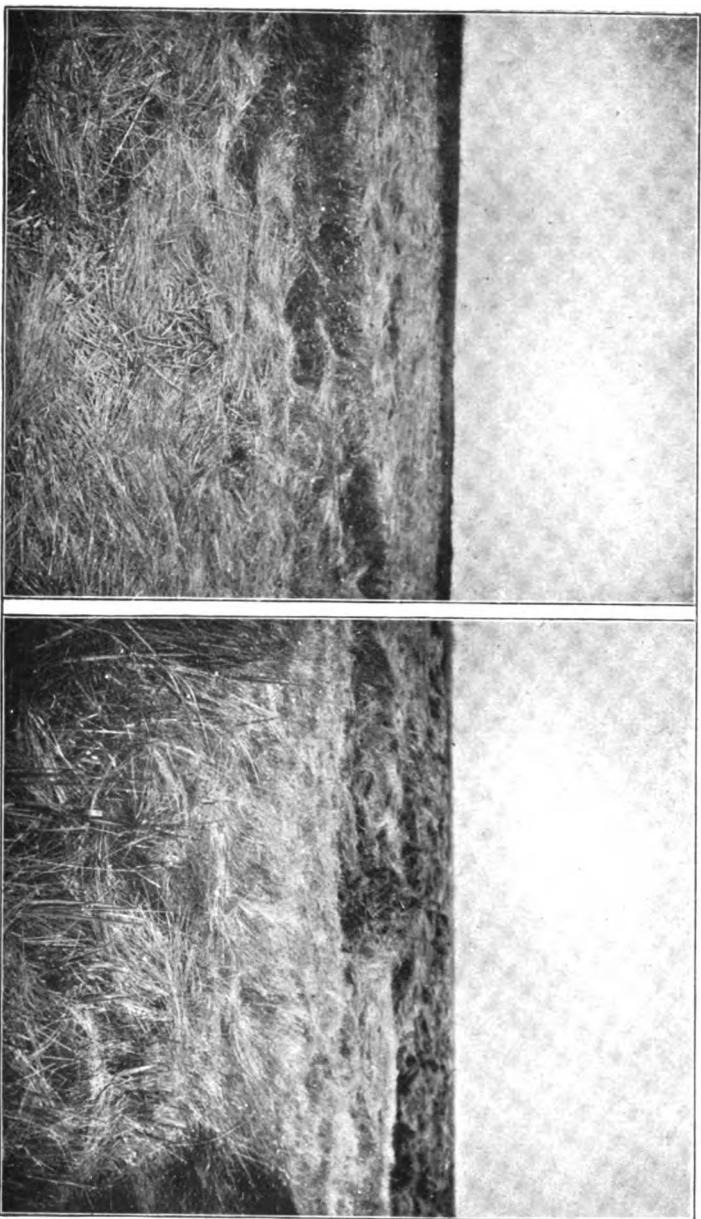


PLATE II.

To the left an area which, in 1903, was a quagmire, in which the ditchers sometimes sank to the waist, and absolutely useless: now cuts one and one-half tons per acre and is improving. To the right an area in sedge in 1903: now cuts four tons of good hay per acre and all work done by machine.

more territory around the edges of the marsh, and \$5 a ton was paid for the crop. With the introduction and increase of the glass industry the demand for hay to be used as packing increased steadily, and yet greater areas were cut. And in order to get at these areas the cutting was done in winter, after the meadow was frozen solid, for at no other time could the product be carted off. And this was the condition of affairs in 1904, when the mosquito drainage was done by the city, but under the supervision of the writer. It might be said here that this drainage work was not looked upon with any favor by owners and haymakers, the latter especially protesting vigorously. One man threatened to smash the ditching machine and yet another promised to shoot the first man that set a spade into his property. The work went on, nevertheless, and altogether nearly 400,000 feet of ditches went into this 3,500 acres.

The results are as follows: On the Hamburg Place section, where in 1903, on an area nearly one mile square, about 100 tons of hay were taken off during the winter, 250 tons were carted off in 1904, only one year later. The meadow has hardened up right along, and in 1907 nearly the entire area was cut by machine, and a crop of 800 tons, valued at \$7.50 per ton, is harvested. Yet a worse place was the area, about one by three-fourths of a mile, known as the Ebeling tract, little more than a sunken meadow before 1904, from which no more than thirty tons of usable grass were obtained. After the ditching the meadow began to rise and improve, and at present writing is at least seven inches above its 1903 level, and correspondingly improved in texture. The crop has increased from thirty tons to 600 tons, not quite so good as the other, but worth an average of \$7 per ton. Other areas which had theretofore produced nothing are now being cut. The total cut in 1903 was between 1,000 and 1,200 tons; the 1907 crop will come close to 3,000. And that is not the limit of productiveness.

Forty years ago the Elizabeth marshes, containing about 2,200 acres, were quite generally cut over and good crops of hay were obtained. There was considerable ditching done, but it was not kept up and as the marsh was crossed and cut up by the railroads without regard to the drainage system, matters became gradually worse; the meadow rotted, the black and salt grass was replaced by sedges and other useless stuff, and less and less was cut each year until, for a decade past, little or nothing has been cut from

the area west of the Central railroad. Where as much as 5,000 tons had once been harvested, less than a thousand tons were harvested in 1903. In 1906, ditches were cut in the southeastern section of the meadow in the course of the mosquito work, and an area on which hip boots were needed in that year can now be safely traveled dry-shod. Where we found sedge and useless grasses over two-thirds of the area in 1905, on that same proportion we now have good salt and black grass. In another year, if the ditches are not interfered with, the sedge will be practically out. The balance of the area was ditched early in 1907, all the work being completed early in July. Shallow depressions that have been water covered and mosquito breeders for twenty years are now dry and covered with the salt-marsh flea-bane. The grass which was ten to twelve inches high last year is now twenty to twenty-eight inches high and much more dense. For the first time in nearly twenty years hay is being again cut in areas west of the railroad and in the area between Great Island, Elizabethport and the Central railroad.

In draining the Shrewsbury river marshes in 1904, the same sort of opposition from hay producers was encountered that we met on the Newark marshes, and it was objected that the ditches cut up the land and made work harder. Nevertheless, the work was done and the result is a crop just double—mostly from longer, thicker grass. Before 1904, two tons per acre was considered a good crop; now, good and bad together, it averages four tons, and local conditions furnish a market that pays \$10 per ton!

The work done during 1907 has not had a chance to show any marked results except that in one drained area, where the grass was cut early, the second growth was so great that it will be cut again and a second crop will be harvested, a thing that was never done before and which there is no reason for not doing on a large portion of the better marsh, annually.

In South Jersey, work has been done only in Long Beach township; but in those sections that were ditched in 1904 the grass is more than twice as long and dense as in the unditched areas. The production of salt hay is quite an industry in this marsh section along the Barnegat bay, and most of it is baled and sent to New York or Philadelphia. The price now is \$7 per ton, at the station, and during the season at some stations, like Manahawkin, 100 tons per week will be shipped. There is scarcely an acre of

marsh that is now cut over that cannot be made to produce from 50 to 100 per cent. more by proper ditching.

One of the areas drained in 1903 was simply a mud flat with little vegetation of any kind and none that was of any value. In 1904 it grew up in sedge and was distinctly higher, also it was possible to walk on it without sinking. In 1905, salt grass began to come in, and in 1906 a crop of hay was made and sold. When



Figure 1.

The salt meadow grass, *Spartina patens* Muhl. : after Britton and Brown.

I last saw it, in the summer of 1907, it had a heavy crop of salt grass, and black grass was obtaining a foothold. A mud flat had been turned into a paying meadow. Only a few ditches were needed to produce this result, and nothing was done from the time they were put in until the spring of 1907, when they were cleared of accumulated rubbish and some sedge that had worked its way in. As the ditches were necessarily shallow, because the sod was thin and on a sand base, this was an exceedingly good record.

Needs of Salt and Black Grass.

These grasses are usually found together and thrive under very similar conditions. For packing there is little to choose between them, the salt grass being, perhaps, a little the better. For feeding, the black grass is much the better and is much more relished by stock. Both grasses demand for their best interests a *live* as opposed to a *stagnant* meadow—a soil in which water *circulates*. In a stagnant meadow, where water lies in pools, the tendency is to rot out these grasses and sedges take their place if anything at all comes in. If the meadow is too dry the grass gets thin, wiry and short. There should be ditches enough to keep the surface dry, and enough more to keep the soil wet. Mosquito drainage looks only to making the surface soil dry, and it may easily be, in some instances, that this will not be enough to give the best crop results. There should be ditches enough to take all surface water promptly and to carry water at high tides to every portion of the ditched area: It is almost as important to let water into some places as it is to take water off others.

How may Salt Marshes be Reclaimed.

There are two recognized methods of reclaiming salt marshes—dyking and drainage—and they obtain quite different results.

Dyking means, briefly, keeping out all sea water by means of dams and, by means of gates or otherwise, allowing the water that accumulates behind these dams to escape at low tide. On a high meadow, with little drainage and no large creeks or streams, this may be done without much difficulty and very simply where there is considerable rise and fall of tide. On a low meadow or one remote from the direct shore, receiving much drainage from the interior and cut with larger creeks, where the difference between high and low water does not exceed two feet, tide gates are not enough and some arrangement must be made for getting out the water that accumulates behind the dams.

In a dyked meadow the characteristic vegetation of a salt marsh disappears and that characteristic of the upland or fresh-water swamp takes its place unless the land be cultivated. And it changes

further. In the quotation from the report of the Geologist, with which this essay begins, is this paragraph which will bear repetition: "Where the marshes have been embanked and improved they have shrunk considerably. Instances have been noted where this shrinkage or settlement amounts to three feet."

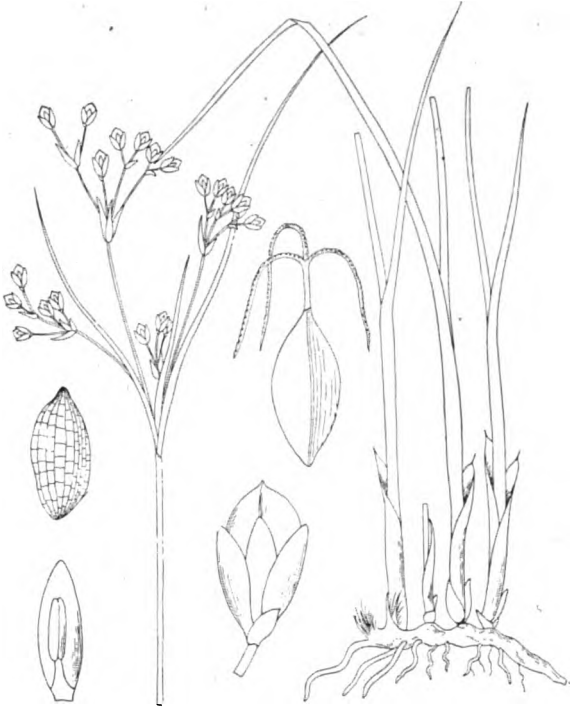


Figure 2.

The black grass, *Juncus gerardi* Lols. : after Britton and Brown.

If my explanation of the formation and elevation of these marshes be now referred to, this will be readily understood. As the salt water drains out of the turf layer and fresh water takes its place, disintegration of the root mass begins. If the soil is turned or plowed or otherwise cultivated this process is increased in rapidity, and what was a high spongy turf becomes a thin layer of very rich vegetable mold. Six inches of turf will reduce to one inch of soil, and as the water drains out of the lower layers the soil becomes more compact.

Completely dyked marsh is salt marsh no longer: it is reclaimed agricultural land, suitable for agricultural purposes. It will grow good crops of celery, onions and other truck for many years without much addition to the soil, and it requires the same care and cultivation as other agricultural land to secure best returns.

To keep this reclaimed land in its reclaimed condition requires the constant supervision of the dykes and keeping them in proper condition. The tide gates must be constantly looked after and periodically renewed, and as the meadow sinks there must be means of getting rid of the accumulating drainage water behind the dykes.

A dyked marsh is necessarily a stagnant marsh, because there is no circulation of water, and if the water is not taken out as it accumulates it becomes a morass. Some of the dyked marsh in Hudson and Gloucester counties is in precisely this condition. Nevertheless, proper dyking and attention to the elimination of surface drainage results in perfect reclamation for agricultural purposes and is practically the only method of obtaining that end. I have been in Holland long enough to get some information as to their way of doing things, and to get abundant practical illustration of the variety and amount of produce raised on these reclaimed lands. It should also be noted in this connection that in Holland looking after all dams and dykes is a State affair, and it can be done by no other authority anywhere if satisfactory results are to be maintained.

Drainage means simply a provision for getting rid of the surface water on a marsh by means of ditching and thereby improving its texture and the value of its crops. It is not reclamation, strictly speaking, for it preserves the marsh as such, and the land keeps its characteristic crops. It is reclamation only in the sense that mosquito-breeding places are eliminated and its productive power is increased.

To produce its maximum effect it must be proper ditching and of this there is very little in the State of New Jersey except such as has been put there in the course of the mosquito work. Much ditching has been done in some localities; but the ditches were, as a rule, wide and shallow; in a few years such ditches become clogged with vegetation that starts from the sides and bottom, and as personal effort in improvement seems to exhaust itself in placing the ditches, no permanent benefits were derived.

A proper ditch is just wide enough to carry all the water that comes into it from the area it is expected to drain, and deep enough to get through the turf layer and well into the mud below it. Our

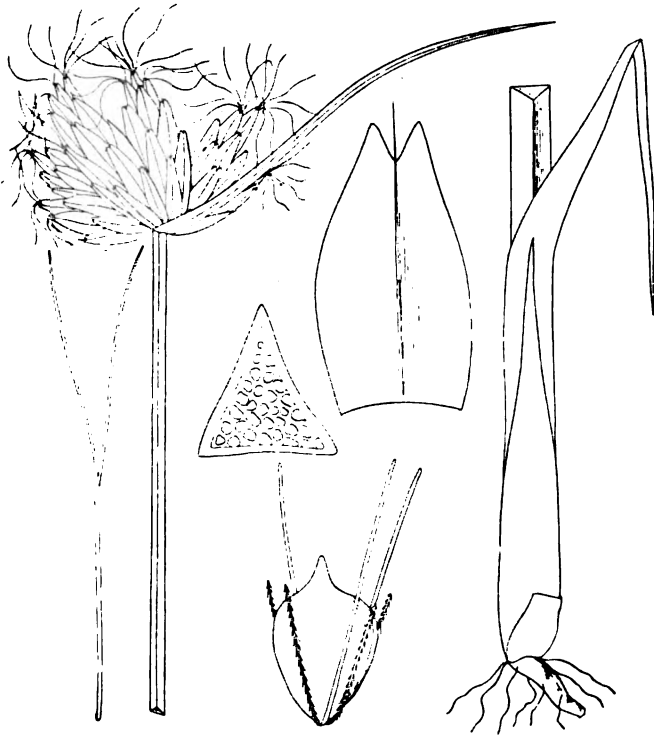


Figure 3.

The three-square grass, *Scirpus americanus* Pers. : after Britton and Brown.

ditches are mostly ten inches wide and thirty inches deep, and only when intercepting or connecting ditches are needed are they made wider on even very soft meadows. The deeper the ditch, the better it acts, until the low-water table on the marsh is reached, and that is not coincident with the mean low-water line, but often much higher. This was well illustrated on a partly-drained marsh on Staten Island, where two ditches were cut without outlets. In these the water level was about eighteen inches below the surface and there was a tidal variation of several inches, although the ditches were fully half a mile back from the shore. The distance

of this permanent level varies as the marsh is high or low, and it is a matter of some importance in the mosquito work, because all holes that extend below this level must be either spur-drained or filled. A ditch, such as I have described, will draw the surface water for a distance of 100 feet on each side of it.

The marsh surface has been already compared to a sponge, but it lets out its water even more readily than a sponge and from the surface it absorbs it more readily. The first thing that happens on a marsh when the surface-water level is lowered is that all the bare spots, representing former pools, become covered with vegetation. This is as likely as anything to be the salt-marsh flea-bane, which makes a rank growth in such places, or it may be the sea pink. This is the first step in lightening up the soil and admitting air. And as the water goes down and the air gets into this turf, it rises and becomes more porous. So long as it is occasionally covered by salt water or is ditched so as to keep a circulation of salt water in the soil, this root mass will not decay, but will rather increase. Sedge is likely to come into the bare places the second year, and this, with its large and vigorous roots, lightens the soil still more and elevates it more nearly to the general marsh surface. Then come the grasses in due order and the shallow depressions disappear in the general level of the surface. A properly-drained marsh never stagnates, never packs or sinks, but tends ever to rise and to add to the thickness of the turf layer. When there is a uniform surface of salt or black grass, elevation becomes very slow, especially if the crop is cut regularly, and a meadow in this stage remains productive indefinitely if properly looked after. And this raises the question of how much looking after a ditch needs.

Again, referring to what has been said of the character of the marsh, it will be seen that a section cut out of the turf leaves a gap that will not fill up of its own accord for decades, provided the section goes through the sod and into the mud below. In Massachusetts I saw ditches only six inches wide that had been in service continuously for more than ten years, and while they were almost obliterated above by the closing in of the surface vegetation, they were open to the full width below—in the mud. Some thirty years ago or more, an attempt was made to reclaim a section of the Newark marsh adjacent to Waverly for commercial pur-

poses, and a number of deep ditches, about twelve inches wide, were put in. For some reason the enterprise failed and was abandoned. The ditches were left to themselves and when the meadow was surveyed for mosquito work they were found still sufficiently effective to keep the meadow in fair condition. I was curious, however, to learn just what had happened to them, and in the spring of 1907 had them cleaned out—some 65,000 feet, all told. It proved that they were simply choked with an accumulation of dead grass and decaying vegetable matter, easily removed with a hook, and when this mass was taken out the ditches acted as well as ever. The sides were as sound and vertical as ever in most cases, and when circulation of water was restored the meadow again drained perfectly.

It is safe to say that, properly placed and properly dug, ditches will last a lifetime if not interfered with, and need patrolling only once or twice a season to remove accidental obstructions or any accumulation of grass or other vegetable matter that may fall into them in the process of harvesting the crop. Where ditches empty into the bay directly, or into some large rivers, it may be necessary to look after the outlets at shorter intervals to prevent obstruction by sea weed and the like.

This process, without changing the character of the territory or the crop it bears, puts it into a condition to produce an annual income per acre which compares very favorably with the value of the average farm crops in the State with very much less labor in the production of the crop. There is no reason, either, why these lands should not be assessed at the value that they are capable of producing, like all other farm land, and why a township consisting mostly of marsh land should not have quite as much income as is obtained from an equal area of average farm land.

As to the relative cost of draining and dyking and the cost of maintenance, that is all in favor of the drainage. An average salt marsh can be drained for about \$12 an acre, and on a large marsh area the average cost per acre of mosquito drainage is much less. The cost of maintaining the ditches need not exceed \$1 per annum per acre and would probably be less. No effective dyking could be done at any such rate, especially as, in any case, ditching would have to supplement it to get rid of the surface water. An area once dyked and placed under cultivation cannot be restored as a salt

adoption of some scheme to secure this improvement will add at least \$2,000,000 to taxable values within the State and should add at least \$250,000 to the annual income of the owners of the lands.

The mosquito work will help matters to some extent. It will render areas comfortably habitable that are now practically abandoned because of mosquito infestation, and it will furnish the basis upon which more elaborate work can be grafted.

The study of the soil structure of the marsh lands, their possibilities in growing upland crops and the other questions relating to the development of this kind of land is in the hands of other members of the Station staff who will report in due time.

Lest it be claimed that the statements here made are based on insufficient observations and apply only to small areas, it may be added that since this mosquito work began in a practical way, in 1904, we have drained and had under more or less continuous observations some 15,851 acres of salt marsh, and have placed a grand total of 2,215,524 feet of ditching. Some of the work has been done by hand and some of it by machine; some has been paid for by individuals, more by municipalities and most of all by the State. All the elements of cost and maintenance are known, and there is no estimate or guesswork anywhere. In the report for 1907 the exact cost of each drained area will appear in detail and also where the ditched territory is to be found.

All the estimates of increased values are conservative in the extreme and take into account the agricultural values only. In New Jersey, and especially near our larger seashore resorts, this is telling only a small part of the story.